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A Survey of Solver-Related Geometry and Meshing Issues

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Solver Specific Mesh Checking - Loci/Chem & Vogcheck

- Loci/Chem developer Dr Ed Luke determined 4 grid criterion that effected convergence (“stiff solution”)
  1. Convexity
  2. Volume Ratio
  3. Face Angle
  4. Face Twist
- Based on these parameters each grid is given a grade: Excellent, Good, Poor, Marginal, or Unusable

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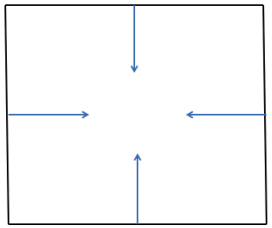
Solver Specific Mesh Checking

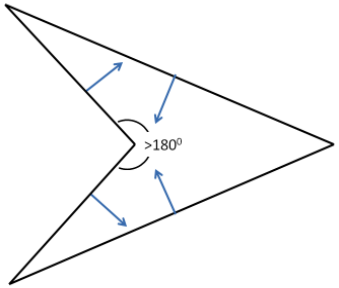
- Vogcheck

1. Convexity
   - A convex polygon is one that has all interior angles less than or equal to 180^0
   - *Vogcheck* defines a non-convex cell as one that the cell centroid is inside the cell when viewed from each face
   - Any non-convex cell in the grid will make the rating Unusable
2. Volume Ratio
   - Defined as the volume ratio of the cells on each side of a face
   - Excellent grid has ratio <10 and the maximum recommended value is <100
   - A large volume ratio decreases the flux from the neighboring cell thus slowing, or stiffening, the solution
     - Defined by the discretization equation

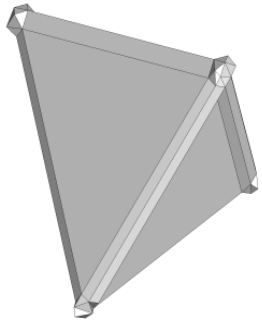
Convex



Non-Convex



1000+ Volume Ratio Cell Cluster



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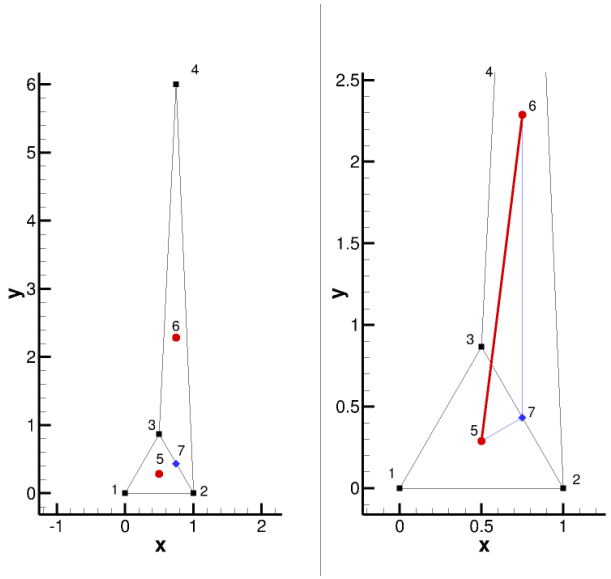
Solver Specific Mesh Checking

- Vogcheck

3. Face Angle
   - Defined as the maximum angle between the cell centroid and face center
   - Excellent grid has values of $<100^0$ and the maximum recommended value is 150^0.
   - Sample triangles would have angles 6-5-7 and 5-6-7 of 52^0 and 8^0, respectively
4. Face Twist
   - Defined as the normal projected distance to the plane that passes through the face center.
   - Excellent grid has values $<10^0$ and maximum recommended value is $<30^0$

Cell Face Angle Sample



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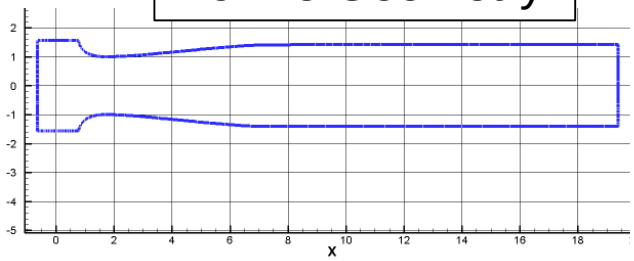
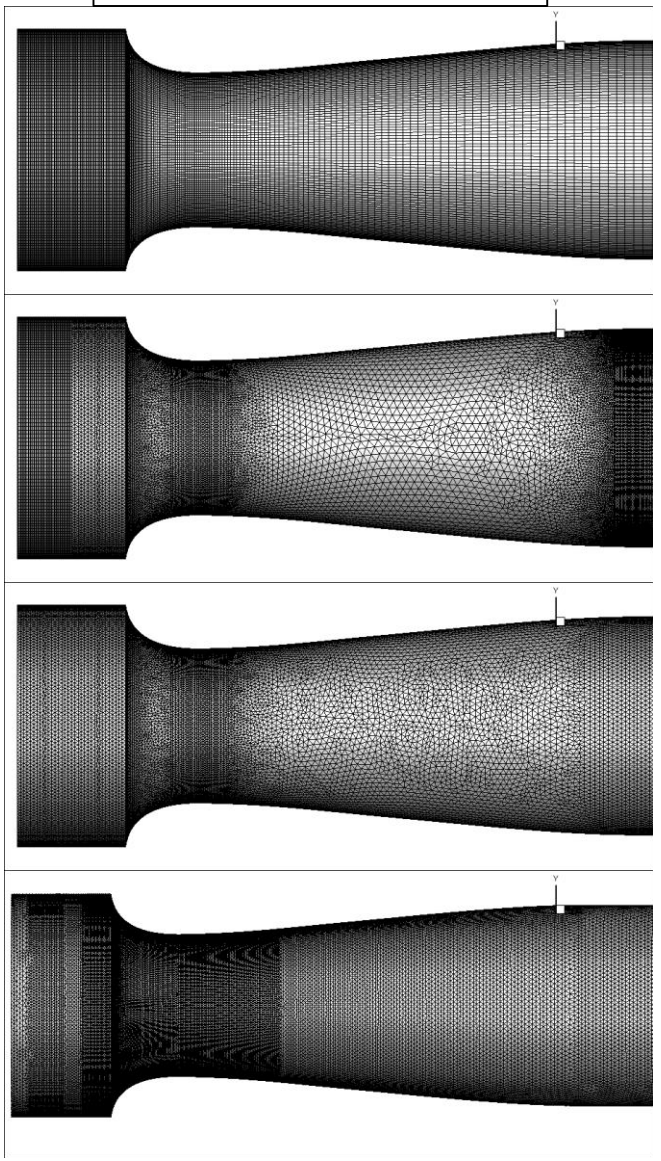
Solver Specific Mesh Checking
- Geometry & Grids

- Axisymmetic Nozzle with A/A*=2
  - Mach Number of 2.2
  - Nozzle extended to highlight boundary layer growth and shock formation
- 4 surface grids generated
  - Pointwise [3] – Quadrilaterals and triangles
  - VGRID [1] – Only triangles
- 7 volume grids generated with same boundary layer growth
  - Pointwise [4] - Combination of surfaces and boundary layer types
    - Marginal and Good ratings
  - AFLR3 [2] - Same surface with tets and prismatic layers
    - Excellent ratings
  - VGRID[1] – only tetrahedron
    - Unusable rating

Nozzle Geometry



Surface Grids 1 - 4

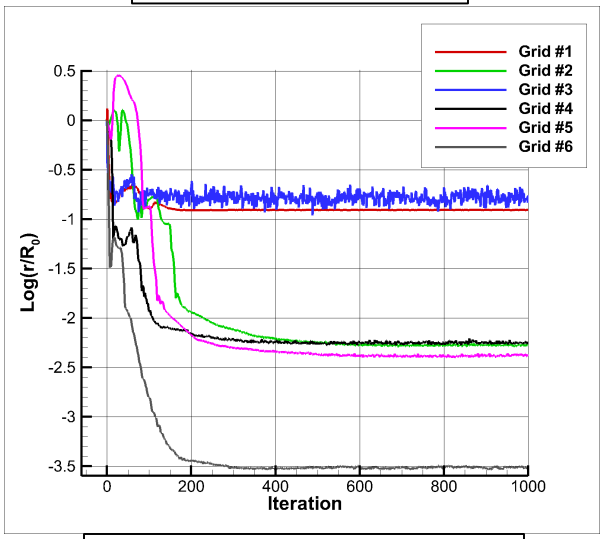


Solver Specific Mesh Checking

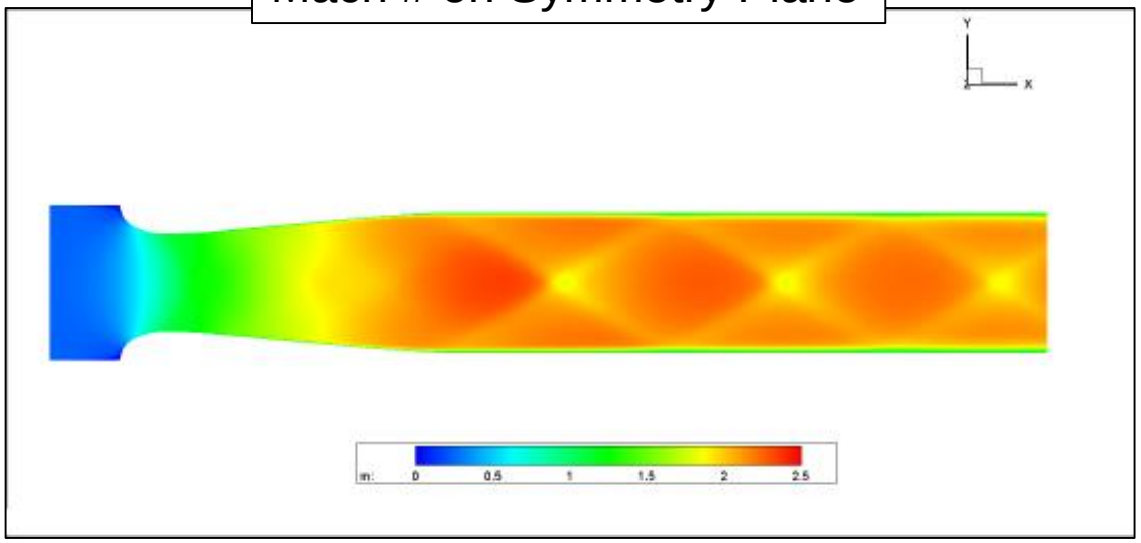
- Results

- Loci/Chem CFD flow solver
  - Initial conditions of 1 atm at 300 K
  - Inflow Conditions: $P_0/P = 10.69$, $T_0/T = 1.97$
  - Roe inviscid flux scheme
    - Most cases had to be run with the adaptive HLLE scheme
    - VGRID grid would not run with Roe scheme
  - Spalart-Allmaras turbulence model

Convergence



Mach # on Symmetry Plane



Centerline Mach #